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COMPLETE SPECIFICATION

Method for producing True Appearance of Solid Objects from Plane Pictures thereof

I, ROGER LANNES DE MONTEBELLO, a French citizen, residing at 108, East 35th Street in the City, County and State of New York, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a method for making pictures of solid objects appear more real, so much so that they will actually appear to be the objects themselves with their real texture, thickness and depth.

More particularly the invention relates to novel methods of procedure in the two stages of the invention—i.e., in:

1. The taking of the picture;
2. The development or production of the picture to be displayed.

The first stage of one embodiment of the invention involves a method for arranging, setting and lighting the subject for the purpose of making a sequence of photographic exposures, the sequence to be completed with great rapidity, such as in a fraction of a second when necessary. This stage also involves provision of means for special lighting necessary for high-speed sequential exposures. This stage also involves novel apparatus to taking the high-speed sequential exposures.

The second or production stage of the invention involves a method, utilizing the impressions or pictures taken in the first stage, to secure (a) black and white master negatives, or (b) color separation set of negatives, or (c) full color positives. Thereafter this stage also involves obtaining pictures of the whole or parts of the object to be combined with the prints derived under (a), (b) or (c), to give the desired illusion or effect of my invention, such prints being obtained by photographic, electrostatic or ink printing means, such as offset, letterpress, gravure and the like.

The results of the first two stages (taking and production stages), such results being printed photographically or otherwise as generally indicated above and in detail below, are then displayed in a special manner and this may also involve means to emphasize and accentuate additionally the illusions or desired effects.

Many efforts have heretofore been made to provide a truer appearance of reality of solid objects on plane prints of the same. Although some have met with mediocre success by giving an illusion of depth or third dimension under certain limited angles and at certain limited distances, none have been very successful and none anyhow have been able under all normal conditions of observation to defy detection or to make one really believe that the real object is actually present.

I have found that the difference in the ocular impression perceived upon looking at, on the one hand, a plane picture, and on the other hand the object or objects themselves, does not depend essentially on the effect of relief (or stereoscopy). I have found that the difference between the ocular impression produced by the picture and the ocular impression produced by the real object resides essentially in the difference between the brightness of the various parts of the real object or group of objects and the brightness of the corresponding parts of the image. Thus the brighter the lighting of the object, the greater the difference between object and picture. For instance, a dull, diffused and low light on actual solid objects makes them appear flat and

to look more like a plane picture, when they are viewed from sufficient distance to weaken the stereoscopic effect of the two eyes. However much care is taken in the reproduction of the actual colors on a picture, it cannot give the illusion of the actual presence of the solid object itself as long as the scale of brightness of its different parts deviates appreciably in the corresponding parts of the picture from a real object brilliantly lighted and thus presenting great contrast between its various parts. Moreover, the source which lights an actual object is generally either seen or perceived, as well as the object itself. In contrast, on an ordinary picture even if the mind does not register it, the eye notices easily that no actual source of light is present where the image suggests that it should be. Furthermore, the actual light surrounding the picture—i.e., the light of the room or location in which that picture is observed—acts on the whole surface of the said picture equally (the picture being plane) showing obviously its flatness, either when such light is moved or if its brightness or color changes. In contrast, when a real object is observed, the eye detects the shadows and highlights to change proportionately to the changes in the source of light itself. Thus it is necessary to provide means of producing a pictorial image that will on the one hand show the proper scale of brightness, and on the other hand seem to be modified like a three-dimensional object by the changes in the surrounding light in at least two of its possible changes, brightness and colour, if not movement.

According to the present invention a process of making a composite picture of plane reproductions of an object comprises making a plane reproduction of the object lighted by at least one source of light which by its position provides shadows and contrast and so creates a good appearance of relief, making another plane reproduction of the same size of said object in the same condition and position but lighted by a source or sources other than that used while making the first plane reproduction, placing one of said reproductions in front of the other in exact register therewith to form a composite picture so that when said composite picture is viewed by transmitted light with the presence of the transmitted light being concealed from the viewer the viewed composite gives the impression that the object itself is present. During the making of the second plane reproduction with the object illuminated by said other source or sources, the object may also be illuminated by the first source at such brilliance as will cause no more than slight shadows on the object. The composite may be displayed using a frame or a front light or both to create the impression in the observer that he is seeing the subject illuminated only by the front light.

Fig. 1 is a perspective front view of one possible arrangement of a selected object with one suitable lighting set-up, showing schematically the light rays from the first phase of lighting;

Fig. 2 is a view similar to Fig. 1 but illustrating the second phase of the lighting;

Fig. 3 is a side view of the arrangement for display shown in Figs. 1 and 2;

Fig. 4 shows a photographic negative made using the light source A only;

Fig. 5 shows a negative made from a positive derived from the negative of Fig. 4 emphasising the highlights. This Figure also suffices as an illustration of a negative made by placing a second film behind the first so that the latter is very underexposed;

Fig. 6 shows a photographic negative made using the light source B only;

Fig. 7 shows a negative made from a positive derived from the negative of Fig. 6 emphasising the deep shadows;

Fig. 8 is a front view of the laminated positive as seen by reflected light only;

Fig. 9 is a front view of the laminated positive but as seen by transmitted light only;

Fig. 10 is a front view of the laminated positive as seen by the combination of both reflected and transmitted light;

Fig. 11 is an exploded view of the composite laminated black-and-white photographic print;

Fig. 12 is a diagrammatic side elevation view, in exaggerated dimensions, of the laminated black and white photographic print of Fig. 11;

Fig. 13 is an exploded view of another form of composite laminated black-and-white photographic print;

Fig. 14 is a diagrammatic side elevation, in exaggerated dimensions, of the laminated black-and-white photographic print of Fig. 13;

Fig. 15 is an exploded view of a composite laminated print printed with inks in color;

Fig. 16 is a diagrammatic side elevation, in exaggerated dimensions, of the print of Fig. 15;

Fig. 17 is an exploded view of another form of composite laminated print printed with inks in color;

Fig. 18 is a diagrammatic side elevation in exaggerated dimensions of the print of Fig. 17;

Fig. 19 is an exploded view of a third form of composite laminated print printed with ink in colors;

Fig. 20 is a diagrammatic side elevation in exaggerated dimension of the print of Fig. 19;

Fig. 21 is a front perspective view of one possible form of the box and frame for the presenting and displaying of the laminated prints;

Fig. 22 is a cross-section of the box and frame shown in Fig. 21;

Fig. 23 is a side view of one possible arrangement of lighting effect in connection with the viewing box and frame and which will emphasize the illusion;

Fig. 24 is a fragmentary side elevation view of another form of the front section of the viewing frame.

In carrying out the invention a composite plane picture is to be produced which will be viewed by the observer by transmitted light and in combination also, in varying degrees by reflected light.

The transmitted light is behind the picture, but the existence of the transmitted light is and must remain unknown to the observer who will thus be convinced that he is viewing the picture only by reflected light. Such conviction is very important in providing the desired impression that the real object is being seen.

The reflected light source can be a single source or several sources. It may be the ordinary lighting in the room or location or any common natural or artificial lighting. The observer will be conscious of this normal lighting substantially as he would be in viewing the object itself.

But in addition to the actual existence of that front lighting, there will appear to be one or more sources of reflected light concentrated in front of the picture and seeming to light the object at one, or several angles. This or these imagined sources will appear to come from one or more points within a protruding frame structure surrounding the picture; such imagined source not being visible to the observer.

Sometimes to heighten this effect a real source may be placed outside the frame where the observer will see it. Its purpose will be either to make the observer think that source is the main source or at least an important source. Its purpose may also be to provide a fixed or flashing outside light made to neutralize the uncontrollable and varying surrounding light in the location; but such visible source will serve primarily to light the frame and surroundings but not the picture, since it will be of such a strength as to provide some reflected light on the image but not enough to neutralize the transmitted light coming from behind the image.

In order to create the above-mentioned effect on the picture given by the flat front lighting and also the illusion of concentrated front light in the frame with the picture actually lighted from behind, it is necessary to make a composite from different impressions or pictures taken with the object lighted first only with flat front lighting and then only with a concentrated source placed at an angle in front of said object, or *vice versa*. The pictures must be taken rapidly in sequence, of such subjects as are likely to move to any extent whatsoever; otherwise it will be impossible to make a composite image with both pictures in accurate register.

1. First Stage: Taking The Picture.

Referring to Figs. 1—3, for the purpose of illustration I have taken as the object to be shown a polished ball resting upon a flat background surface, in front of which and spaced from which is a frame 50. The frame is illustrated as of rectangular form and having a central rectangular opening through which the ball and back surface are visible; but other forms of frame may be used. The frame may be of cardboard, wood, metal or other suitable material, preferably with a rough surface having relief when lighted at a narrow angle. A light, rather than dark, color for the frame is preferred although the invention is not limited in that respect. In the first stage two photographic exposures are made of the subject lighted by different sources during the taking of the different exposures.

One concentrated source of light, which for the purpose of illustration is shown as a common electric light bulb, A, illuminates the ball and frame as well as the portion of the back surface which is visible through the frame. The light is at an angle in front of the frame and ball so that it casts shadows. In Fig. 1 the frame and ball are shown as if illuminated by source A alone. Deep shadows 51 and 52 are cast upon the background surface by the ball and by the frame respectively; and a highlight is formed on the upper surface of the ball as indicated at 53.

The concentrated Source A need not necessarily be a single point such as a single lamp but may comprise more than one concentrated source. Thus, concentrated sources at two or more angles might be used but of course too many separated sources cannot be used for that would tend to multiply and weaken the

shadows which should be avoided during the taking of the exposure with the subject lighted by a concentrated source or sources alone.

Of the concentrated sources there is preferably one dominant source. It is necessary in practice that this source, when the picture appears in the finished stage, seem to be within the frame in which the picture is displayed. This will require that this dominant source be placed fairly close to the subject and it must create a sufficient amount of shadow to give good appearance of relief when the subject is seen directly with only one eye. It is very desirable in taking this sort of a fixed picture with the aforementioned lighting that the objects in the subject be so placed as not to create a multiplicity of overlapping shadows and a general feeling of confusion in the picture as a whole. Such confusion cannot be overcome in viewing such a picture, because it is not possible to rely on the stereoscopic effect of the two eyes.

A second and flat or diffused source of light is provided designated generally by the letter B. This source may be a bank of electric lights in any suitable holder with or without a diffusing glass in front of the electric lights. It will be understood that the invention is not limited to any particular form of flat lighting, nor, under conditions explained further, of flat lighting at all, the form disclosed being solely for the purpose of illustration.

Referring to Fig. 2 the frame and ball are shown there as if lighted by the source B alone. This may be compared with the illustration in Fig. 1 wherein the lighting is by the source A alone. It will be noted in Fig. 2 that the frame, the background surface and the ball are quite evenly lighted with the highlight 54 in a different position and less concentrated than when the ball is lighted by the Source A. The diffused shadow 55 behind the ball is not as dark nor as clearly defined as in Fig. 1. The darkest shadow 56 is of small area, directly under the ball and is the only shadow part that even approaches in depth the shadow 51 in Fig. 1 cast by the source A.

According to my invention the subject will be photographed as lighted by the concentrated source A and immediately thereafter and in sequence, and from exactly the same position, a second exposure on another film will be made of the same subject lighted by only the source B; or vice versa.

It will be understood that with a subject which will remain stationary (such as the ball illustrated), there will not be the same necessity for rapid sequential exposures as would be the case if a portrait of a living person or of a flower, or the like, were to be taken. Such subjects are likely to move, though even slightly, in a fraction of a second, and hence if two exposures need to be taken under different lighting conditions, it is of the utmost importance that the sequential exposures be taken as closely together as is possible, preferably within a fraction of a second.

For the purpose of describing the invention, it will be sufficient to assume that the object to be photographed is stationary or relatively slow-moving so that extremely high-speed sequence exposures need not be taken. It will be understood, however, that the invention is equally applicable to both types of subjects and the only variation in application between a still and a moving subject will be in the speed of operation of which the photographic equipment employed need be capable. Existing photographic equipment may be used without change for photographing still or relatively slow-moving subjects, as long as all precautions are taken for the camera to stand firmly so that no movement or vibration will occur while changing the plate or film.

II. Second Stage: Printing.

The photographing separately of the subject when illuminated by the source A and when illuminated by the source B can be for the purpose of producing either a black and white or a colored picture since the invention can be practised with both. Firstly I will describe the production of a black and white picture.

(a) Photographic printing—black and white.

According to my invention I build up a composite picture on a transparent plate. The parts thereof which result from the photographing of the subject when lighted only by the concentrated source A will be seen by transmitted light. The parts of the composite picture resulting from the photographing of the subject when lighted by the flat source B will be seen by reflected light mainly. Hereinafter the parts resulting from the two different exposures are designated by the letters A and B with exponential numerals.

As illustrated in Fig. 4, A^1 is a preferably underexposed (for most subjects) negative made by photography on a black and white film, preferably on a film giving very wide latitude an low gamma so as to give detail in the highlights and shadows. This negative must be also underdeveloped to give relatively low

density so as to increase the range. (This negative was made with the subject lighted by source A alone). It will be understood that when I refer to under-development, I have in mind using a weak developer.

From single negative A^1, I make a positive A^{11} (not illustrated) on film or plate by contact printing or projection (enlargement). This positive is over-exposed thereby giving detail only in the highlights. From this positive a second negative A^3 (in Fig. 5) is made. So as to reduce even more the detail in the shadows and medium-dark areas, and thus to leave detail only in the highlights, this second negative A^3 is under-exposed.

I now have two negatives A^1 and A^3 (Figs. 4 and 5) of which A^1 has detail in both the highlights and shadows and A^3 has detail only in the highlights, A^1 being a thin usually underexposed and underdeveloped negative as stated. From negative A^1 I print a positive A^2 (Figs. 11 and 12) on a plate P^1 of a high contrast and great density emulsion well developed in order to obtain a dense transparency in which the parts corresponding to the deepest shadows are very black and dense and the brightest highlights are completely clear. The purpose of the positive produced from A^1 as just described is to provide means which in co-operation with lights transmitted through the transparency will supply shapes, shadows and highlights produced by light A and, as the image is on the whole very dense, the transmitted light must be of such intensity as to give througout the intermediate range the details that were in the object. The brighter the light, the better the result, provided that the density range of the plate is calculated in accordance to that brightness of transmitted light.

As an alternative way of making the positive A^2, particularly for especially difficult or fine work, in lieu of making an underexposed negative A^1, a still better result is obtained by placing two films, one behind the other in the camera, and giving the proper exposure, illuminated by the concentrated source as in Fig. 1, to provide an overexposure on the front film and an underexposure on the back one which the back coating of the front film helps in obtaining. A supplementary neutral density thin filter may also be used between the two films when the emulsion speed of the back film, different from the front one, is not slow enough in itself. The back film will be slightly out of focus. As a result the highlights (main or only details appear-on that back film) will be slightly bigger than normal which desirably will enhance them. Those two negatives can be used either successively or together in register as a single negative for printing the positive A^2. In this instance the back film is used as a negative A^3. The front would be equivalent to A^1.

Having now a positive A^2 of a wide range of density, it becomes necessary to provide for the maximum brightness on the most brightly lighted areas of the subjects (highlights). For this purpose I print on a transparent film a positive from the negative A^3. That second positive A^4 (not shown) gives detail in the highlights only. Practically, only the highlights will show. Now referring to the left half of Figs. 11 and 12 I coat on top of positive A^2 (which is on plate (P^1) a layer of white Eastman Kodak "Transfax" (Registered Trade Mark) or similar medium in which the parts affected by light appear in development. Then using the second positive A^4, I print on the "Transfax" layer giving WA^5. Highlights which in the subject are produced by almost total reflection will be clear. "Transfax" is a high contrast material, therefore if the highlights on the negative A^3 are wide and have diffused edges, the positive A^4 must be half-toned, i.e. by using a screen between the negative A^3 and positive A^4, so as to obtain gradually diminishing highlights and shadows.

"Transfax" is a light-sensitive material including or consisting of a bichromated hydrophilic colloid containing an aqueous dispersion of a water-insoluble soft synthetic resin capable of drying in a continuous film, such as polymethylacrylate or polyethylacrylate. The sensitizer may be ammonium or potassium bichromate.

I have now a composite print in two layers (A^2 and WA^5) which is intended to be seen only by transmitted light. To this I add, in the following manner, a composite print to be seen by reflected light, the above white layer WA^5 serving as its necessary white background.

As illustrated in Fig. 6, a negative B^1 is made by photography on black and white film with the subject lighted by the source B only. So as to show detail in shadows and no detail in the highlights, this negative is very overexposed; and it is normally developed or slightly underdeveloped.

From B^1 negative I make a positive B^{11} (not illustrated) which I underexpose so as to obtain no detail in the highlights and medium lighted areas.

From positive B^{11} I make another

negative B^3 (Fig. 7) which I overexpose to further reduce the detail so that the only detail will be in the shadows and even there the detail will be minimum. Thus only the darkest shadows will appear.

I now have two negatives B^1 and B^3 coming from the exposure of the subject to the B lighting. (See Figs. 6 and 7).

Using the negative B^1 (normal contrast no detail in the highlights) I print a positive B^2 on a plate P^2. (See Figs. 11 and 12). This positive is underexposed and underdeveloped giving a thin print with details in the shadows further accentuated by such underexposure. The printing is done with the negative reversed (i.e. turned over) so that a reversed positive will result. This reversal is necessary because later I place the image-bearing side of the plate P^1 with the composite A print against the image-bearing side of the plate P^2 bearing the B print, so that the two prints are against each other and, of course, in register.

As an alternative to printing B^2 from B^1 in the manner described, the highlights corresponding to the light A may be enhanced by superimposing the negative A^3 on the negative B^1 and printing both at the same time. This will add to the image B^2 clear places corresponding to the highlights 53 of print A^2 so that the transmitted light passing through P^1, A^2, WA^5, B^2 and P^2 will shine through unimpeded in these places.

Another alternative for the same purpose which, however, will avoid the need to register B^1 and A^3 in printing is to make the exposure to produce negative B^1 while the source A at reduced brilliance is still illuminating the subject thus to avoid creating visible shadows on the subject already illuminated by the source B. Thus the desired highlights 53 will appear but no shadows from source A. Nevertheless, some slight shadows, hardly visible, may appear but the objective should be, insofar as practically possible, to avoid all shadows from source A. It will readily be understood by those familiar with photography that in stating that the A source is lit at reduced brilliance, I am simply indicating a relationship of brilliance of the A and B sources. To explain more fully, if the shutter speed and iris opening are set for photographic material of a given sensitivity, and it is decided to use photo materials of lesser sensitivity, the brilliance of both the A and B sources will have to be increased in order to attain the necessary amount of exposure. Obviously, under some conditions (when both A and B sources are lighted during exposure of the B print) the A source may be at the same brilliance it had when the A print was being exposed, but then the B source will be proportionately brighter; hence the A source will appear to be lit at reduced brilliance.

On top of the B^2 positive I arrange a further print in order to obtain (in the final composite print) a black that is darker than obtainable with any single layer of photographic emulsion. I make this further print from negative B^3 (detail in shadows), getting a positive print B^4 with very black shadows. Except for the shadows this layer will be clear. Like the printing of the B^2 positive, the positive B^4 is printed in reverse. The desired results can also be obtained by hand retouching or by using the positive B^4 to make a silk screen stencil and using the silk screen printing process or the dye transfer process or the "Carbro" (registered Trade Mark) process to make a print directly on the print B^2. In each case a very light-absorptive—i.e. very black—ink, dye, or pigment is used.

Referring to Fig. 11 it will be noted that the glass plate P^1 is at the left. Next to it is the layer bearing the positive print A^2 which is dense and dark with the deepest shadows very dense. On top of A^2 is print WA^5 made by the use of "Transfax" (as in Fig. 11) in which the highlights 53 appear, that print WA^5 being white except at the highlights where it will be clear.

Next is the positive print B^4 just described which is clear except for the deep shadows. Next, and between B^4 and the top plate P^2 of glass is the positive print B^2 which has detail in the shadows and medium areas and is clear at the white or very light areas and may also remain clear at the places of highlights 53 of light A and is a thin print so that it and B^4 can be seen by reflected light, being backed up by the white WA^5.

Instead of printing on two plates, it is alternately possible to build up the picture on one plate as illustrated in Figs. 13 and 14. In that case the glass plate P^3 has the positive print A^2, made from negative A^1, printed thereon as previously described, giving detail in light and shadows plus range and density.

Then on a separate film I print the normal or halftone positive as necessary identical to A^4 using negative A^3 in the manner above described. Then I make a very light halftone negative B^1H (not shown) from an intermediate positive (not shown) made from B^1. Now on "Transfax" or the like I print using positive A^1 (to give clear highlights 53 resulting from

source A) and the weak halftone negative B^1H, in register. The result is WB^2. Because I am printing on "Transfax" or the like, the parts affected appear in development. Hence use of B^1H negative and A^4 positive here causes the "Transfax" to wash off more or less in the shadows produced by B^1H and the highlights 53 produced by A^4 and remain more or less in the light part corresponding to B^1H. That is desired because under the shadows there is a print A^2 which, being very dense, looks black by reflected light and which will show through as is necessary for the more or less transparent shadows and medium values to be visible by reflected light. (See Fig. 3).

Next, on top of the "Transfax," i.e. the print WB^2 resulting from A^4 and B^1H, I print the deepest shadows. To do this a positive produced from the negative B^3 is used to make a silk screen stencil. With this stencil I print the deepest shadows using very deep black as described in connection with making B^4 of Fig. 11.

The image produced in any one of the ways above described will be a black and white photographic image and will be displayed as hereinafter described, using a transmitted as well as reflected light. The image produced in the foregoing manner may be hand tinted to add colour provided that the colours are very transparent and applied thinly.

The above-mentioned processes suitable for small quantities are impractical for mass production. Thus one of the objects of this invention is to provide means for producing the images in big quantities at the lowest possible cost and minimum time, which is easily provided by printing with inks, or by electrostatic printing, on any suitable transparent or translucent base.

(b) PRINTING IN COLOR WITH INKS.

The taking of the pictures in such case is done with the same sources of illumination as described above. Also if the object is not stationary, the exposures must be made in rapid sequence; but if immobile the need for rapid sequential exposures is not essential and existing photographic equipment can be used under the same conditions of care as above.

In describing the printing it will be understood that the method of printing for mass production is not limited since the printing itself can be done in several ways.

I start with any sheet as a base, such as transparent or white plastic or white paper of very fine composition and grain, with the proper degree of translucency to permit the passage of light from behind which is spread uniformly over the entire sheet.

The base sheet can be the foundation of a decalcomania, if desired from which the print can be transferred to a final support. For the purpose of describing a specific example but not in the sense of limiting the invention, I will now describe the invention starting with a transparent sheet or plate.

The photograph taken with the subject lighted by concentrated source A may be on "Kodachrome" (registered Trade Mark) or like single plate or film; or it may be by the color separation process method on color-separation negatives. Commonly these negatives are taken on black and white film through colored screens to produce negatives registering each color desired. If "Kodachrome" or the like is used, it is necessary thereafter to make color-separation negatives anyway; but it is handier to take the original in "Kodachrome" than with a color-separation one-shot camera, because the equipment for the latter is more cumbersome.

The color-separation negatives should be weak or thin negatives with a wide range from highlight to deep shadows, equivalent to A^1 in the previously described black and white photographic print.

Then the necessary plates for printing with inks, i.e., blue, magenta, yellow, are made from the color separation negatives as usual in the printing art. An electrostatic process with charged powders may also be resorted to at this stage instead of the usual plate engraving method.

The engraved plates are then used to print with transparent but very dense inks on the basic transparent sheet P^4.

It may in some subjects be necessary to mix some opaque pigment with the inks to cut down even more the amount of transmitted light. The negatives used to make the plates, being of very low contrast, the use of dense inks brings back the desired real contrast existing on the actual subject photographed. Black is commonly added and is here also to the same or greater density. The result will be A^2c (see Figs. 15 and 16) equivalent to A^2 in the previously-described black and white photographic printing.

The very bright spots should be as clear as possible. Hence letter press printing is not so desirable as gravure. Lithographic printing of the black is satisfactory in some cases. In any event the printing should be heavier than normal printing of transparencies.

Now, having the print A^2c (which

print is to be seen by transmitted light) I print on top of it with white ink, having a suitable degree of translucence and coverage. This white printing is to supply the white areas of the following part-picture B but it may have some blank areas in the highlights. If there are blank areas the light from behind (transmitted light when the image is to be displayed) will be practically transmitted in totality at those places. But if the transmitted light is from a concentrated source and no diffusing surface is displayed behind the print, then the white should have no blank area because the source might become perceivable. Hence, in such case, when a concentrated source of transmitted light is used behind the image, diffusion must be supplied by the picture itself.

The white printing is done with an engraved plate in the following manner:

It will be recalled that in describing the production of the black and white image a negative A^3 was prepared having detail in the highlights only. In preparing a plate to print white ink, a white will be printed everywhere except in the highlight. Hence I prepare a negative similar to A^3 from one or more of the color separation negatives whose equivalent in black and white was A^1. In some cases the highlights are colored; so it is necessary to choose the color separation negative or negatives best showing the highlights. From them a black and white positive $A^{11}c$ (not shown) is made, using the same exposure and development procedure as was used in making A^{11}; and from that positive the desired negative A^2c (not shown) results. It is then used to make the engraving positive plate for the white print WAc.

Having described the production of the part of the picture to be seen by transmitted light, and having covered it by translucent white ink, I now describe the printing of the part of the picture to be seen by reflected light.

1st. With Supplementary Black Printing.

With the subject illuminated by the B source the color separation negatives can be supplied (as with the A source) by an ordinary one-shot color-separation camera or by "Kodachrome" or the like assuming, as before, all precautions being taken for the camera to remain perfectly motionless and the subject not to move between this exposure and the exposure with source A lighting. If "Kodachrome" is used with the B lighting, then from "Kodachrome" I go through the color separation negative process to get color separation negatives. Preferably the negatives are well overexposed so there is a minimum detail in the highlights and a maximum in the shadows. From these negatives the engraved plates are made as usual in printing, and with them I print in very transparent, very thin inks a composite print B^2c, on top of the white printing. Those prints have to be very thin so that they are visible enough by reflected light but can be penetrated fully by transmitted light. The thickness of the printing can be controlled readily since the amount of ink printed ordinarily depends on the amount of pigment on the printing plate, as is well understood in the printing art. This refers to the black as well as the primary colors.

There can be visible shadows even in the blackest parts of a subject. I desire these shadows to appear. Therefore besides the printing of the B^2c positive in colors and with black according to the three-color-and-black process, I print additionally with a supplementary black printing plate prepared as I will now describe.

Since my objective is to produce a plate to print the deepest shadow detail, I take the one or more of the color separation negatives resulting from the exposure to the B source which best show the deepest shadows and I print them photographically to form an underexposed positive which I shall refer to as $B^{11}c$ (not illustrated). Using $B^{11}c$ I make a negative B^2c (not illustrated) which is overexposed so as to accentuate still more the shadows, showing only the deepest, darkest shadows, for example as illustrated in B^2bk in Fig. 15. Using B^2c I make the supplementary printing plate and use it to print additional black B^2bk on top of the composite B^2c color image. In this supplementary printing the ink should be the blackest (i.e. having the greatest light absorption power) available in printing inks. It may be printed thinly, however, so that the colors behind can show through by transmitted light. Since there are colors in even deep shadows to some slight extent, they should appear if possible for true color rendition but when necessary it is also possible to use an opaque ink, as the eye does not easily detect the coloration of the dark areas.

2nd. With Normal and Supplementary Black Printing Combined.

As illustrated in Figs. 17 and 18, without changing the above-described printing of the other colors, it is possible to omit one of the black printings by combining the effects of the two in one printing plate in the following way. The

black printing plate is made from both the B^3c negative, as above, and the negative used for normal black printing; but in this case the latter is kept in very low (thin) contrast so that when the plate made from them is used in printing, using the deep black highly light-absorbent (by reflected light) ink, the result B^2BK is that the deep shadows are as dark as when two black printings were used and the lighter shadows and greys are covered in the amount desired because those areas are printed lighter than normal with the same highly absorbent ink. In Figs. 17 and 18, B^2c^1 is the same as B^2c with the omission of the normal black print.

3RD. WITH MODIFIED WHITE AND WITH ONLY SUPPLEMENTARY BLACK PRINTING.

As illustrated in Figs. 19 and 20 another alternative is possible in the preparation of the image to be seen by reflected light. In the first and second described possibilities of color printing with inks, the A^2c and WAc prints were the same, the difference between the two alternatives being in the black printing for the image B. In the alternative I am about to describe the A^2c prints are the same as before; and the colors (blue, magenta and yellow) B^2c^1 and the supplementary black B^2BK of the B prints are the same as in the first color form, Figs. 17 and 18.

However the normal black plate of the usual color printing plates for the part picture B is not used in this case. Instead, the plate for the white printing is modified so as not to print in the extreme highlights and to fail to print or only very lightly print in the black areas for reasons as will more fully appear presently. To obtain the white printing plate I first convert the normal-black color separation negative into a positive. With this I combine the negative A^3c as used in the first alternative, to make the white printing plate. The plate thus made is a negative of the normal black plate but in addition has clear areas in the highlights 53 as in the positive WA^5. With this plate I print (see Wc) in white on top of A^2c.

The plate for the white printing thus fails to print or only very lightly prints in the black areas and the greys as it is a negative plate; and in the extreme highlights 53 where in the subject there was a total or almost total reflection, the white will not print at all as these parts are positive on the plate. Remembering that I am printing on top of the A^2c color and black layers which by reflected light, being very dense, appear all black, it will be apparent that when the white plate does not print or only lightly prints that black will show through thus supplying the black and greys to be seen by reflected light. At the same time the failure to print in the highlights 53 will permit the highlight to shine through from the back, i.e. the highlights 53 will be supplied by the transmitted light.

In making pictures of some subjects the printing may be on opposite sides of a piece of white translucent paper. In that case the paper will take the place of the white printing on top of the print A^2c. The difficulties of getting in register the A prints, printed on one side of the paper oppositely from the B prints on the other side, can be overcome by adequate care and use of known procedures.

Although I have described three alternatives as examples, it will be understood the invention is not limited to those three.

(c) PHOTOGRAPHIC AND IMBIBITION DYE PRINTING IN COLOUR.

In general printing the picture photographically and by imbibition dye printing in color follows a procedure similar to what I have described, in the respect that the picture taken with the A light source is printed as a transparency to be seen only by transmitted light, while the picture taken with the B light source is printed so as to be seen by reflected light. Between the two prints is a white print of "Transfax" or the like, a layer of white lacquer or a sheet of translucent material or a white layer printed using a silk screen or the like..

Considering first making a picture with the A light source, "Kodachrome" or similar photographic color transparency is used. Here as before it is desirable to underexpose to give a dense image and to accentuate the highlights but, because of the limited latitude of the film, even with the use of color corrective filters, the desire to underexpose can be satisfied only partially. The underexposure of the "Kodachrome" while giving fairly good contrast in the highlights does not give sufficient depth nor enough detail in the dark areas. Therefore I supplement the "Kodachrome" by a black and white positive photographic printing. The negative of this black and white exposure will be made with the A light source simultaneously with the taking of the "Kodachrome"; but the black and white will be very much overexposed because I desire to supplement only the dark areas. It is not desirable to supplement all the areas. It is possible in existing camera equipment to take the two exposures at once on different films. Since the "Kodachrome" film is normally not as fast as black and white film the same exposure that will underexpose the "Kodachrome"

will overexpose the black and white if a fast enough black and white film is used. Even if not sufficient overexposure would thus result, the length of exposure can be increased and a neutral density filter can be used with the "Kodachrome" (against the film) so its exposure will not also be increased.

It is not always necessary to use the supplemental black and white print because, as will be better understood later, the print made taken with the B lighting will compensate to some extent for the lack of detail in the deepest shadows of the A print. Having the " Kodachrome " (which for convenience I identify as AK and the black and white overexposed negative which I identify as Aa^1 (not shown)) I print photographically a positive Aa^2 (not shown) in black and white using Aa^1. This positive can be printed directly on top of the " Kodachrome " by first applying an emulsion layer. The positive will be underexposed to give detail in the shadows only.

Turning now to making the print using the A light source for the imbibition dye process a dye transfer may be used to make the color print equivalent to AK provided the concentration of dye is sufficient to give the desired density. This dye method is advantageous when it is desired to make a larger print or to make a quantity of prints. Also it may avoid the need for the supplemental black and white exposure because in producing color separation negatives greater control can be exercised. The hand-tinting process known as " Flexichrome " (registered Trade Mark) may also be used, in which an ordinary silver emulsion print is hand tinted with colours.

On top of the composite color and shadows print made by dye transfer or " Kodachrome," I apply a white layer by means of a silk screen or with " Transfax " in the manner hereinbefore described to have the highlights clear, or I apply a layer of white-sprayed lacquer or sheet of translucent material. The lacquer or translucent material, however, will cover the whole surface and will cause a loss in the highlights.

The B print to be added to the dye transfer or " Kodachrome " picture is made following the principles hereinbefore described for the B prints in the black and white photographic printing and color printing with inks. In the present cases, the B print is preferably made by conventional dye transfer method on a separate plate or film and laminated to the A print. In making the B print on a separate plate or film the image is reversed so that it can be applied directly against the white layer (which is on top of the A image) without there being any plate or film in between. Alternatively the dye transfer of the B image may be made directly onto a gelatin layer placed as a base on top of the white layer previously applied over the A print.

The printing by the dye transfer method can be controlled, as is well understood by those skilled in the art, so that a very light print can be made. For the same reasons as in the previously-described forms a light print is desired for the B print. Also the light print is desirably supplemented in the black areas in the same manner as in previously-described embodiments of the invention. In supplementing the blacks, black pigment or dye can be applied by dye transfer or " Carbro " process (registered Trade Mark), or ink by the use of a silk screen, either directly or on the back of a transparent film or glass plate.

Thus the result is an A print supplemented or not in the black areas, which will be seen by transmitted light; a white layer or printing on top of that; and then a B print applied by dye transfer in gelatin or as a separate film over the white, the B print to be seen by reflected light.

To display properly the composite plane picture, a special frame or display apparatus is needed (such as is claimed in co-pending application No. 25194/52) (Serial No. 702,125). (See Figs. 21, 22 and 24).

In most subjects there should be a frame around the subject when the picture is taken so that this frame will appear in the picture and will give a comparative surface that will mainly receive the light from the concentrated source or sources A. For best results it is desirable that this frame be made of material which is rough enough to give gradations in light shadows and give an appearance or feeling of the texture of the frame. The purpose of this is to give a psychological reaction by still more giving the impression of the light being in front. Thus it is always necessary to keep in mind that the observer must not get the impression that he is viewing a transparency.

The main object is on one hand to avoid the feeling of transparency and on the other hand to make the observer feel the image and the subject it represents are being viewed by reflected light only. Thus the main source of light should appear to be only in the front part of the frame. The objective is to suggest the concentrated source A which was actually present when the picture was taken. The

flat source is present as the normal room light.

The outside frame about to be described can be used for displaying the image as made either by printing with inks or photographically in black and white or in colors.

The frame is in general outline usually in the same shape as an ordinary picture frame but can be of any suitable or desired outside shape. In the example illustrated (see Figs. 21 and 22) it is rectangular. The front section of the frame has four intersecting planes such as 20, the planes being inclined outwardly and forwardly. They intersect with four other intersecting plane surfaces 21 which incline inwardly and rearwardly—that is, toward the picture. The angle of inclination is of no importance nor is it necessary for the surfaces 20 and 21 to be inclined so as to intersect at an oblique angle. The surfaces 20 can be parallel to the image and can intersect the surfaces 21 at right angles in which event surfaces 21 would be perpendicular to the picture. Behind the surfaces 21 is a parallel-sided frame consisting of plane surfaces 22 intersecting at right angles. These surfaces 22, if visible, are of reflecting material such, for example, as aluminum foil. It is desirable that the surfaces 22 should be offset under the front section of the frame as shown. It is not necessary that they be visible, but it is more practical to make the frame with the surfaces 22 visible.

Behind the surfaces 22 is the composite print I preferably mounted between glass or other transparent plates which are held in a slot or groove or in any suitable manner in the frame. If the surfaces 22 are visible, it is desirable that they be directly adjacent to the picture. It is of course obvious that if the surfaces 22 did not come directly adjacent to the picture, then the picture would have to extend sufficiently so that the space between the surfaces 22 and the picture would not permit the observer to look into the interior of the frame or to see where the picture stops.

The frame or at least the front section thereof may be hollow as at 26 and have rear walls 24. The frame must have a sufficient depth to permit the observer to believe that one or several sources of light are contained within the frame.

As an alternative construction of the front or picture-supporting section the foremost or directly visible part 41 may be either flat or of any shape such as in ordinary picture moldings. (See Fig. 24). The back side 42 of this front surface 41 may be of reflective material and flat, and parallel to the picture, and may intersect another reflective surface 44 perpendicular to the picture whereby the reflective surface 42 is spaced from the picture. The reflective surfaces 44 may intersect a third reflective surface 46 parallel to the picture and overlapping or at least adjacent to its edge. Since all of the surfaces 42, 44 and 46 are reflecting surfaces, it will not be possible for the eye of the observer to detect there is not a source of light in the frame corresponding to the concentrated source A which was present when the picture was taken.

The frame of either Fig. 22 or Fig. 24 has a second or intermediate section comprising four surfaces 27 intersecting to form the walls of a rectangular frame. From each surface 27 a wall 27^1 extends in a direction parallel to the picture I. Walls 27^1 have a trough or other suitable support for the edges of a heat shield. The heat shield comprises two spaced sheets of glass 28 and 30 with a dead air space 29 between them. The purpose of this air space is to insulate the picture I from heat coming from a lamp 31 presently to be described. One or both of the glass sheets may be heatproof or heat-absorbent and also will not be subject to cracking, such as " Pyrex " (registered Trade Mark) glass. One or both of the glass sheets 28 and 30 may be of frosted or ground glass or other similar diffusing glass; but it is not necessary that either be of diffusing nature if the proper reflector hereinafter described is used, or if the picture I includes a diffusing surface.

The third or reflecting section of the display structure comprises a diffusely reflecting member 32. This member 32 need not be of any special form. One form that has satisfactorily been used is simply two convergent sheets of asbestos behind an electric lamp 31. The member 32 need not be of two plane surfaces but could be four, or any number, and need not even be a series of plane surfaces. Any suitably diffusely reflecting means which will give light substantially evenly over the glass plates 28 and 30 and over the picture will be satisfactory. In fact the entire object of the rear section is to supply a strong light which will be distributed evenly over the picture I.

For practical purposes it is probably more convenient to use a single electric bulb 31. I have used satisfactorily the No. 2 photoflood to cover an area of about 11 × 14 inches but for commercial purposes a light of equal brightness and longer life would be more satisfactory. The amount of light diffused on the back of

the image must be several times stronger than any heretofore normally used for displaying transparencies.

Since in available standard incandescent lamps this amount of light develops quite an intense heat, it is necessary that there be provision for ventilating the frame structure. For this purpose the rear or reflector section 32 is separate and spaced by adjustment bolts or in any suitable way from the intermediate section to provide ventilating passage 36. Also the intermediate section is spaced from the front or frame section as by bolts 34 to provide ventilating passages 36^1. These passages 36, 36^1 should prevent entirely the passage of light out through them.

In order to heighten the illusion and thereby to attract attention to the displayed image, the rear light may be flashed off and on rapidly preferably with the period of illumination longer than the period of darkness. The period of darkness should be so short that the eyes do not have an opportunity to lose entirely the after-image. When there is not much light outside, i.e., in the location where the picture is displayed, the rear light may be turned off completely during the flashing. When there is considerable light outside then the rear light will only be dimmed or reduced in brightness.

The flashing tends to heighten the illusion because it gives the same impression that the observer would get if the A light source were turned on and off in the presence of the real object. In other words, shadows and highlights appear when the A light is directed to the real object and disappear when that light is off. So also by turning off the rear light when displaying the image, the same highlights and shadows are made to appear and disappear.

In all the foregoing the light source B has been considered to be a flat or diffused source. However when the picture is taken this B source need not be flat or diffused but may be concentrated or partly so. In that case, in displaying the image a light 60 should be placed outside the frame, as in Fig. 23 in the same relative position as the source B was in when the picture was taken. But this should be done only when the general illumination at the location of display is known in advance to be of such intensity as not to render ineffective the light 60. The effect is to create the impression upon the observer that the shadows in the image which were created by the source B are created by the light 60. This outside source 60 may be turned on and off in order to heighten the illusion of the presence of the actual object. In this instance in contrast to the previously described flashing of the rear display light, it is possible to turn on and off either or both of the front or rear lights; but if both are flashed they should not both be off at the same time. Here again it is necessary that the period of darkness be so short that the eyes do not have an opportunity to lose entirely the after-image.

As above described the rear light used for display has been assumed to be white. However, in order to create a theatrical effect, two or more rear or front lights of different colors may be present, the number and location of the front lights being subject to the limitations hereinbefore stated. By turning on one or another or a combination of these different colored lights, the appearance of the picture may be changed to give an effect similar to that one observes in the theatre when flood lights of different colors are thrown upon the stage. The appearance of reality or in other words the illusion of the presence of the actual object is not lost but on the contrary is retained even though the colour of the rear lights used changes.

What I claim is:—

1. A process of making a composite picture of plane reproductions of an object which comprises making a plane reproduction of the object lighted by at least once source of light which by its position provides shadows and contrasts and so creates a good appearance of relief, making another plane reproduction of the same size of said object in the same condition and position but lighted by a source or sources other than that used while making the first plane reproduction, placing one of said reproductions in front of the other in exact register therewith to form a composite picture so that when said composite picture is viewed by transmitted light (which may be changeable in color) with the presence of the transmitted light being concealed from the viewer the viewed composite gives the impression that the object itself is present.

2. A modification of the process as claimed in claim 1 wherein during the making of the second plane reproduction with the object illuminated by said other source or sources, the object is also illuminated by the first source at such brilliance as will cause no more than slight shadows on the object.

3. A process as claimed in claim 1 or 2, wherein said other source or sources of light give detail in the shadows and

wherein both of said reproductions are transparencies.

4. A process as claimed in any of claims 1 to 3 wherein said other source or sources are diffused so as to cast no strong shadows.

5. A process as claimed in any of claims 1 to 4 wherein the reproductions are made photographically

6. A process as claimed in any of claims 1 to 5 wherein one of said reproductions is a dense transparency and the other is a thin transparency visible by reflected light as an ordinary image when the transmitted light is absent.

7. A process as claimed in any of claims 1 to 6 wherein one or each of the reproductions comprises a series of layers at least a part of said layers being printed photographically.

8. A process as claimed in claim 7 wherein one layer contains translucent white printing to permit one reproduction to be seen by reflected light.

9. A process as claimed in claim 7 or 8 wherein the highlights are accentuated on one of the layers.

10. A process as claimed in any of claims 7 to 9 wherein one of the layers to be seen by reflected light is printed with translucent white and is left clear in the areas of the highlights.

11. A process as claimed in any of claims 7 to 10 wherein the shadows are accentuated on one of the layers.

12. A process as claimed in any of claims 1 to 11 wherein the shadows are accentuated on one of the layers to be viewed by reflected light.

13. A process as claimed in any of claims 1 to 12 wherein one of the plane reproductions to be seen by transmitted light is arranged behind the other plane reproduction which is to be viewed only by reflected light, and wherein one or both of the reproductions are printed in color, for example by colored inks.

14. A process as claimed in claim 13 wherein a layer printed white is provided between the two reproductions to provide the white for the front reproduction.

15. A process as claimed in claim 14 wherein said layer is not printed or only lightly printed in the areas of the highlights so as to provide complete or substantial transparency for the transmitting light.

16. A process as claimed in any of claims 13 to 15 wherein the front reproduction which is to be viewed mainly but not solely by reflected light is printed with very light-absorbent black ink so that the deep shadows have greater than normal depth while the less dark portions have less but adequate depth, for example by being printed more lightly.

17. A process as claimed in any of claims 13 to 16 wherein the front reproduction is provided with black printing in addition to accentuate the deep shadows.

18. A process as claimed in claims 15 and 17 wherein said white layer is not printed or only lightly printed in the deep black or light black areas respectively so that the corresponding areas of the rear reproduction can be seen by reflected light and thus appear black.

19. A process as claimed in any of claims 13 to 18 wherein the rear reproduction is dense but transparent while the front reproduction is highly transparent, for example as the result of being printed with very thin inks.

20. A process as claimed in claim 13 wherein the rear reproduction is provided with additional black printing to deepen the black and dark shadow portions.

21. A process as claimed in any of the preceding claims wherein the rear reproduction comprises a photographic color transparency or a color transparency in which the colors are supplied by dyes.

22. A process as claimed in any of the preceding claims wherein the front reproduction is a colored dye-transfer visible by reflected light but sufficiently transparent to permit the passage of light transmitted through the rear reproduction from behind.

23. A process as claimed in claim 21 wherein the rear reproduction includes in addition a black photographic printing to deepen the black and dark shadow portions.

24. A process as claimed in any of claims 1 to 23 wherein the two reproductions are formed in transparent plates which are arranged face to face.

25. A process as claimed in any of claims 1 to 23 wherein the two reproductions are formed on a single transparent or translucent plate.

26. The process as claimed in claim 1 carried out substantially as herein described with reference to the accompanying drawings.

27. A composite pictorial record when obtained by the process claimed in any of claims 1 to 26.

Dated this 5th day of July, 1950.

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London, W.C.2,
Chartered Patent Agents.

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702,051
5 SHEETS

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SHEET 1

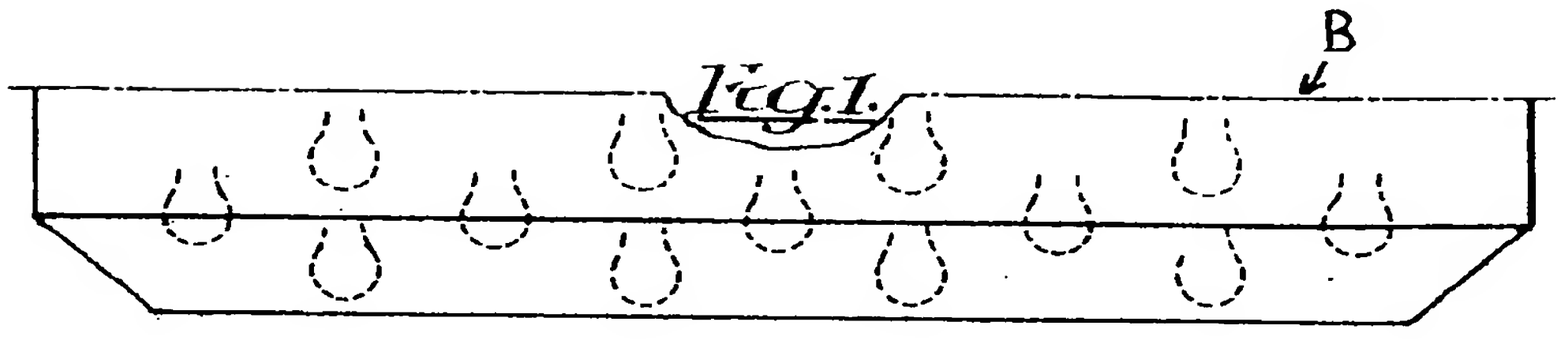


Fig.1.

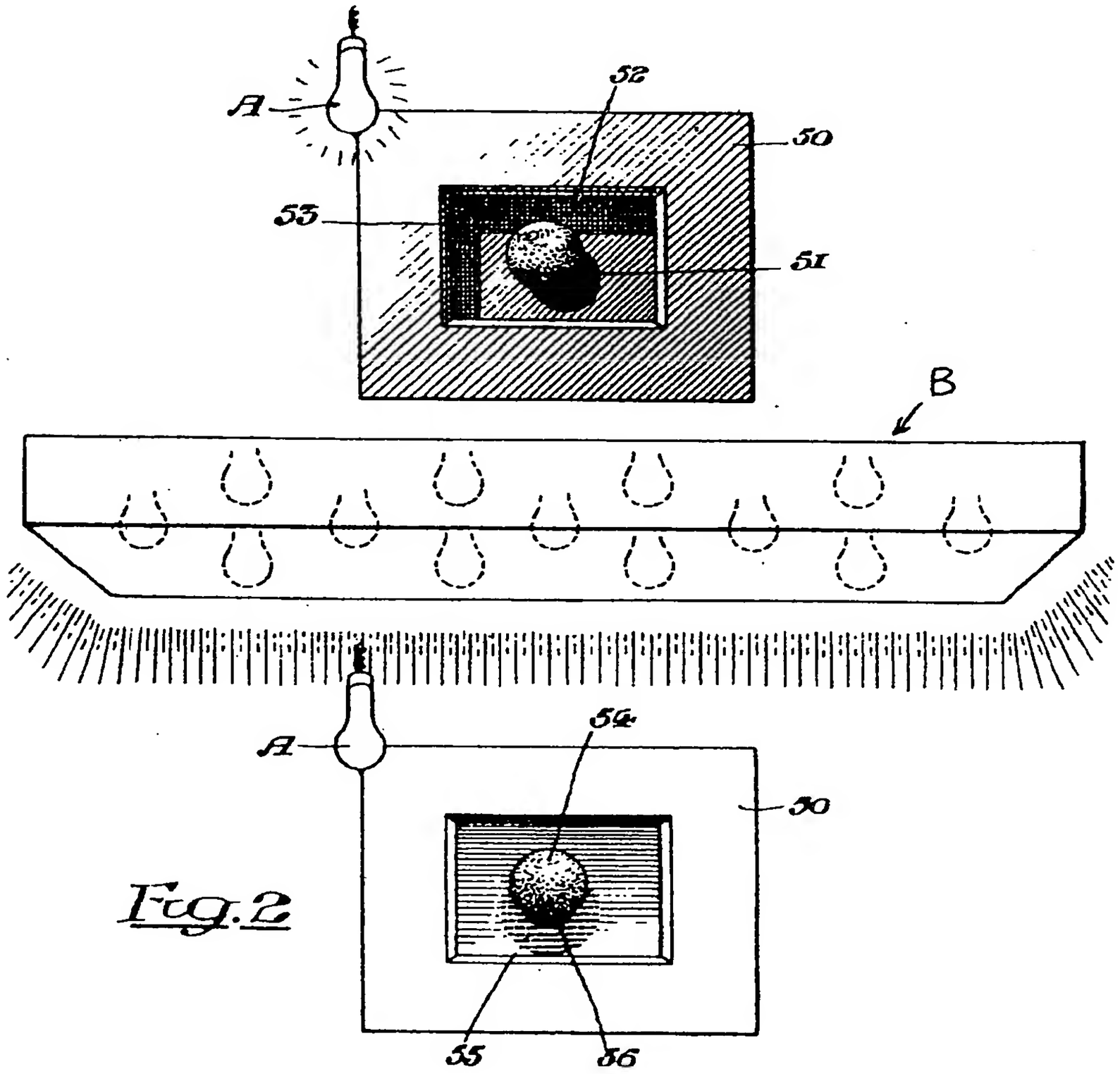


Fig.2

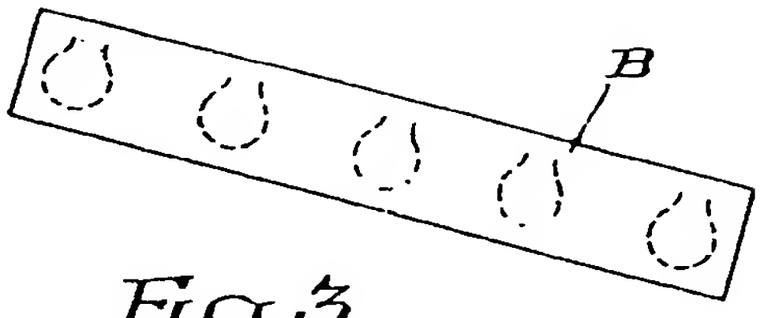


Fig. 3.

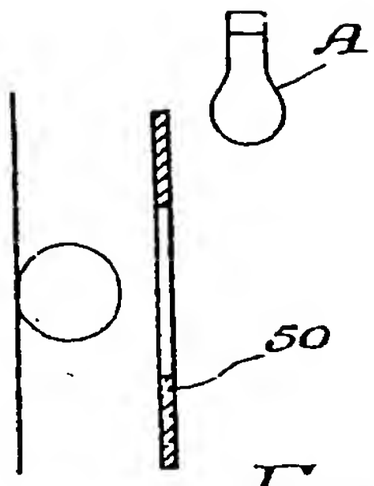
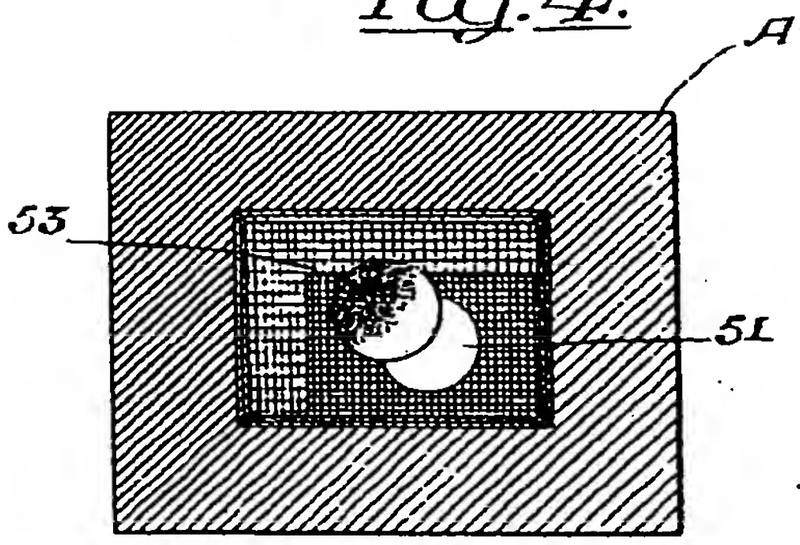


Fig. 4.



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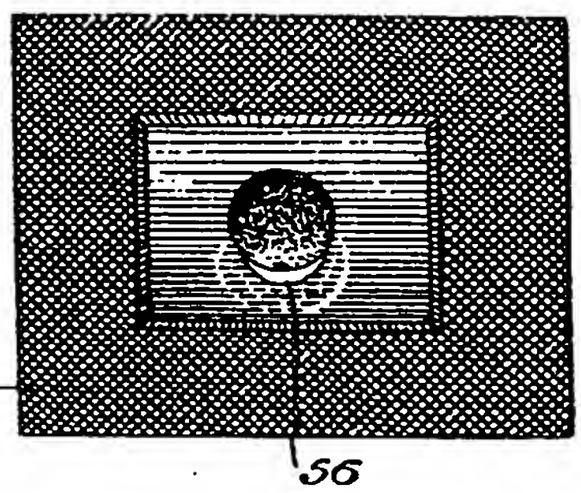

Fig. 6.

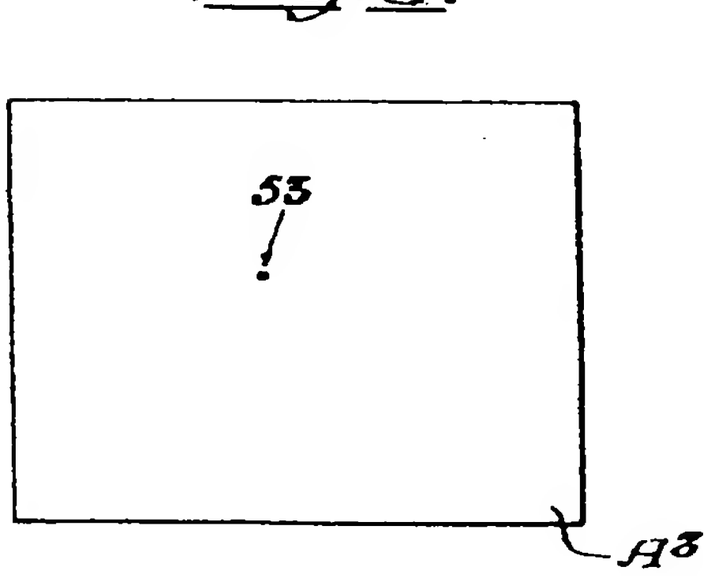

Fig. 7.

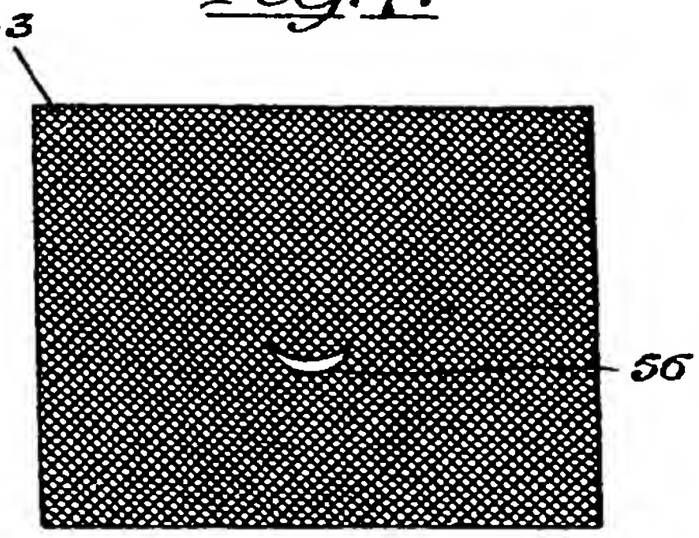

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Fig. 8.

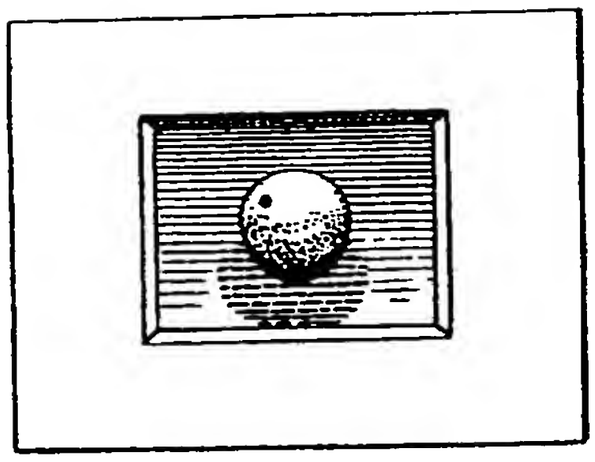


Fig. 9.

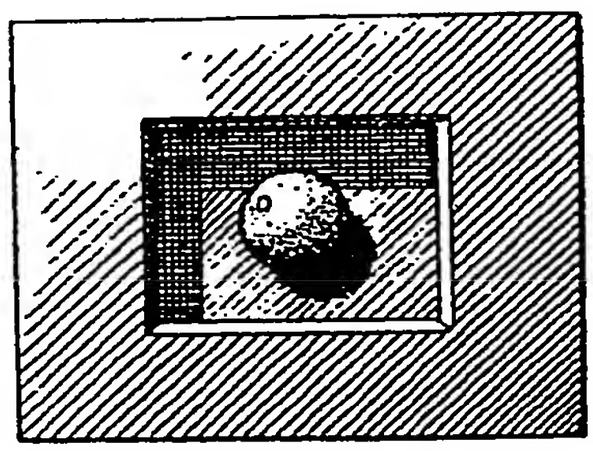


Fig. 10.

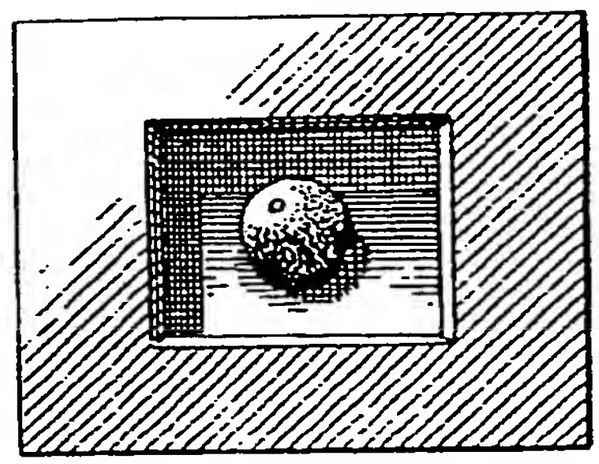


Fig. 12.

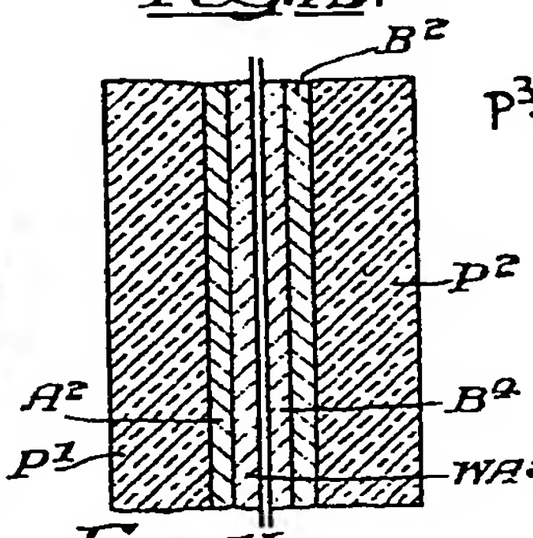


Fig. 14.

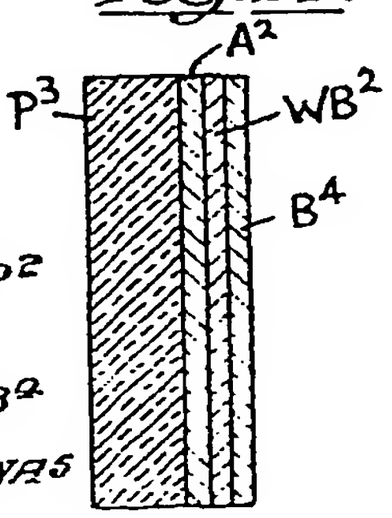


Fig. 11.

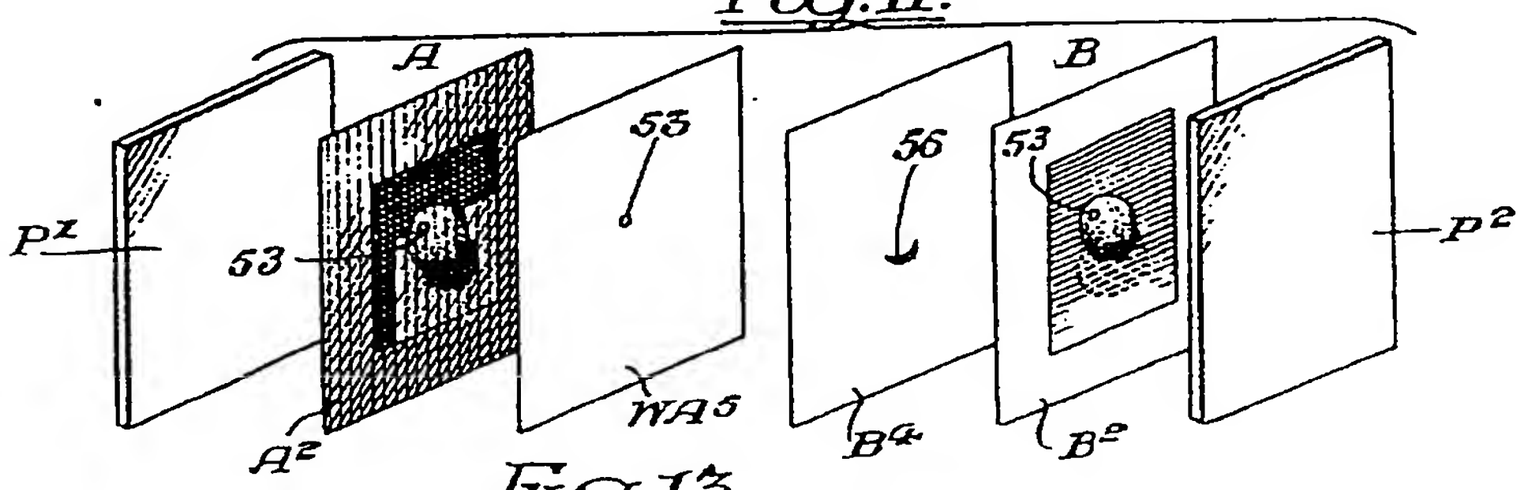
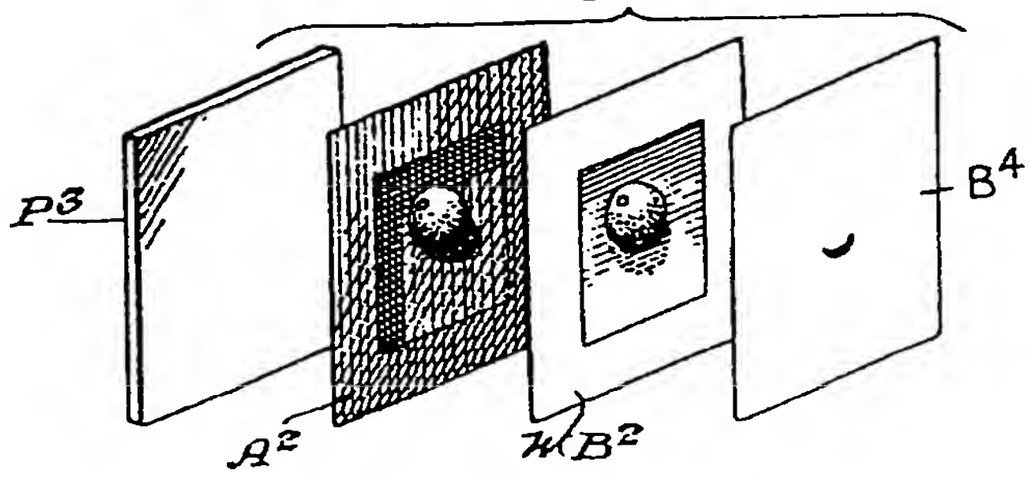


Fig. 13.



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SHEETS 2 & 3

Fig.3.

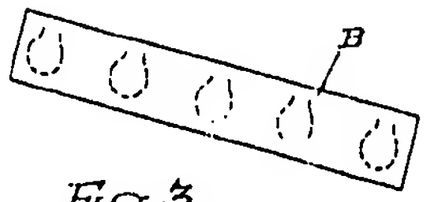


Fig.4.

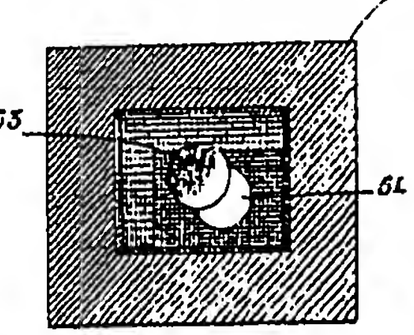


Fig.6.

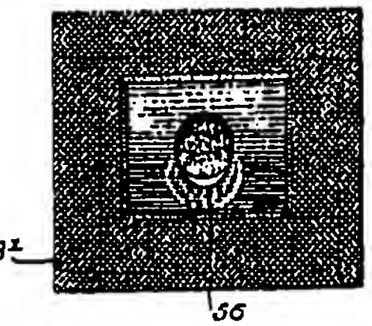
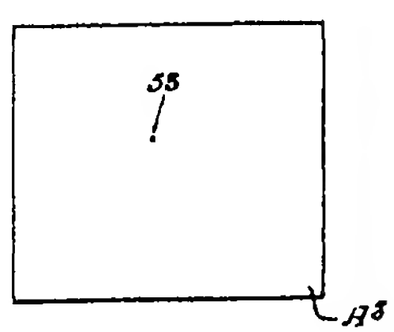


Fig.5.



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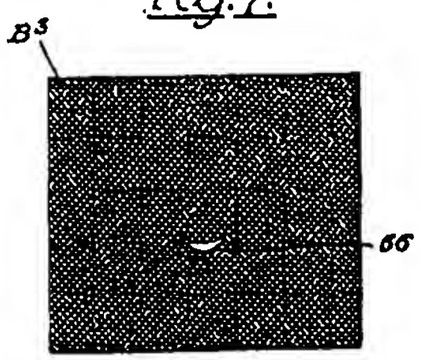

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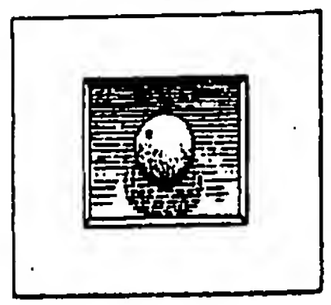

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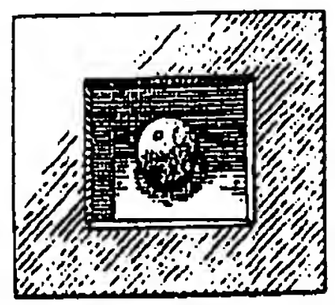

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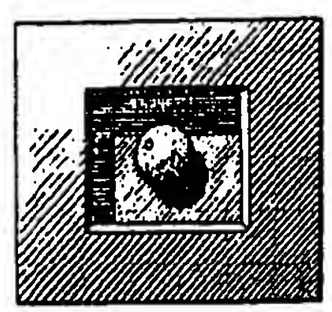

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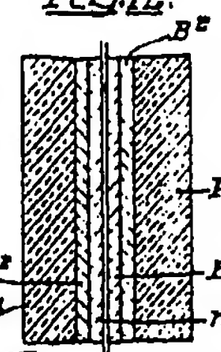

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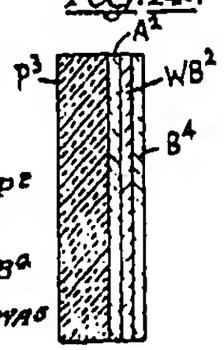

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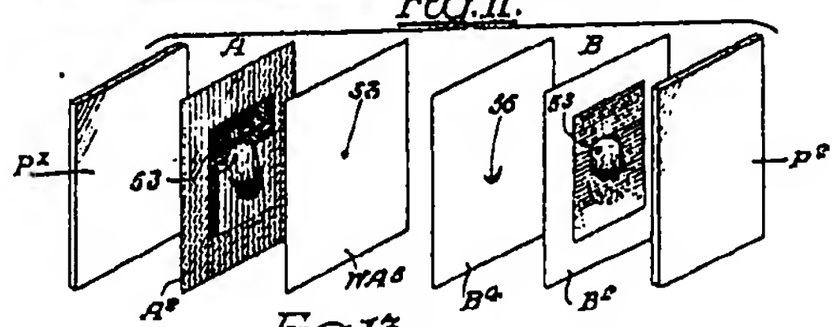

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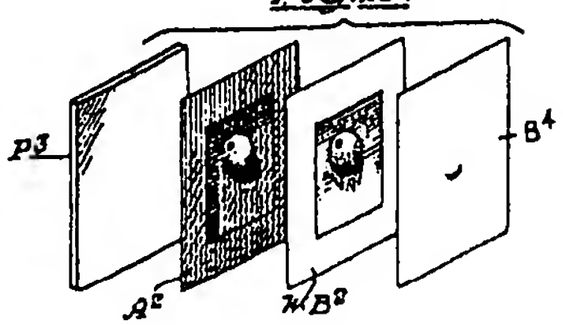

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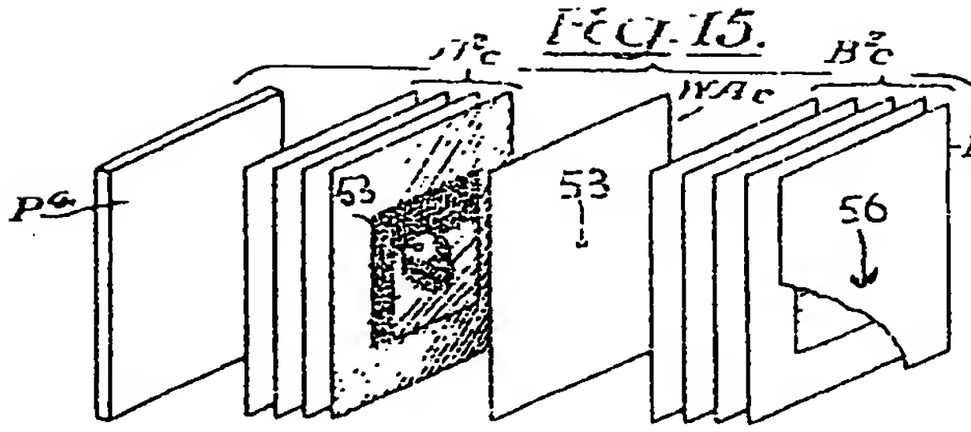

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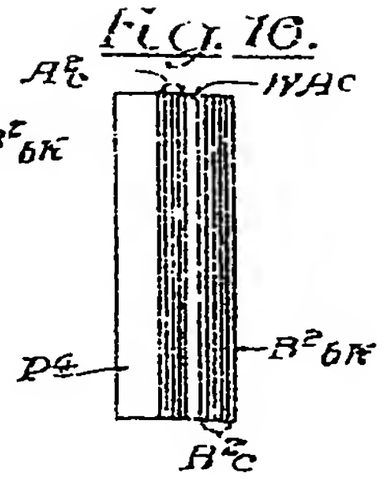

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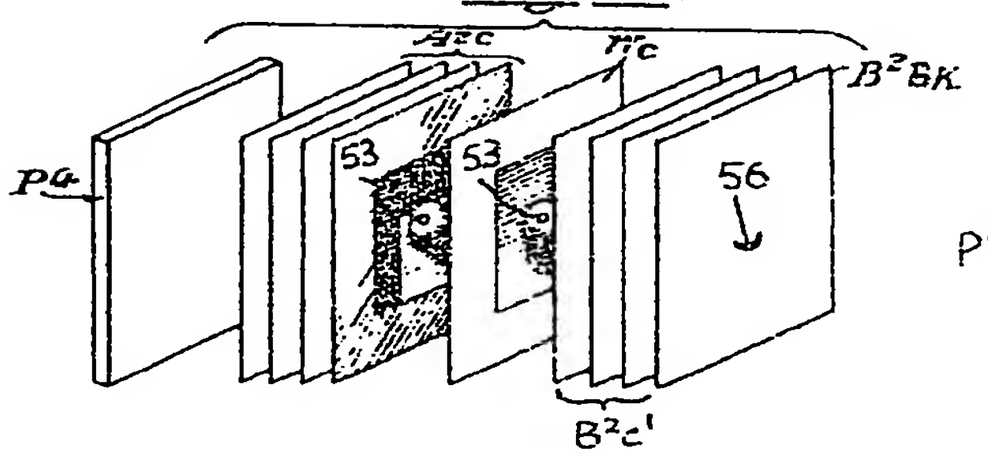

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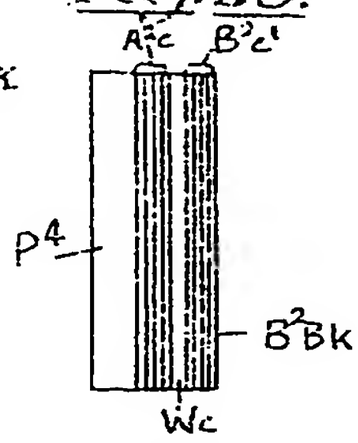

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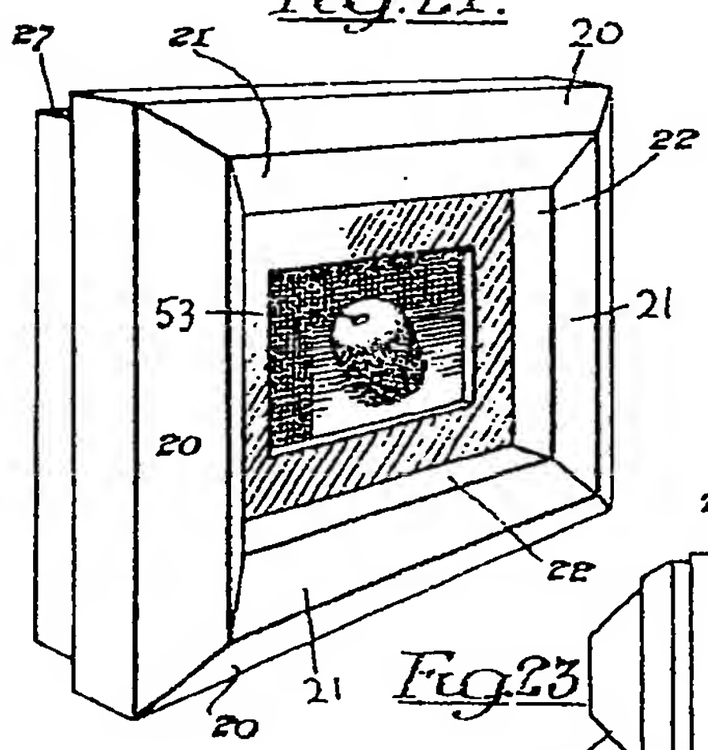

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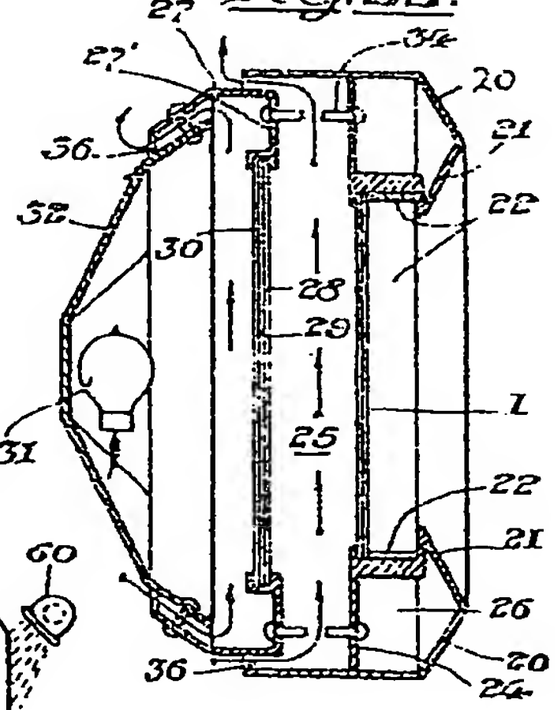
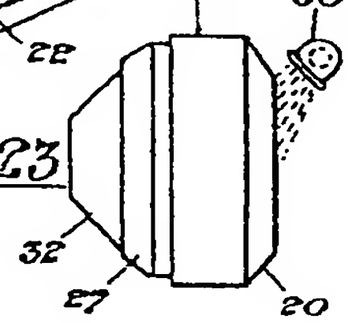


Fig 23



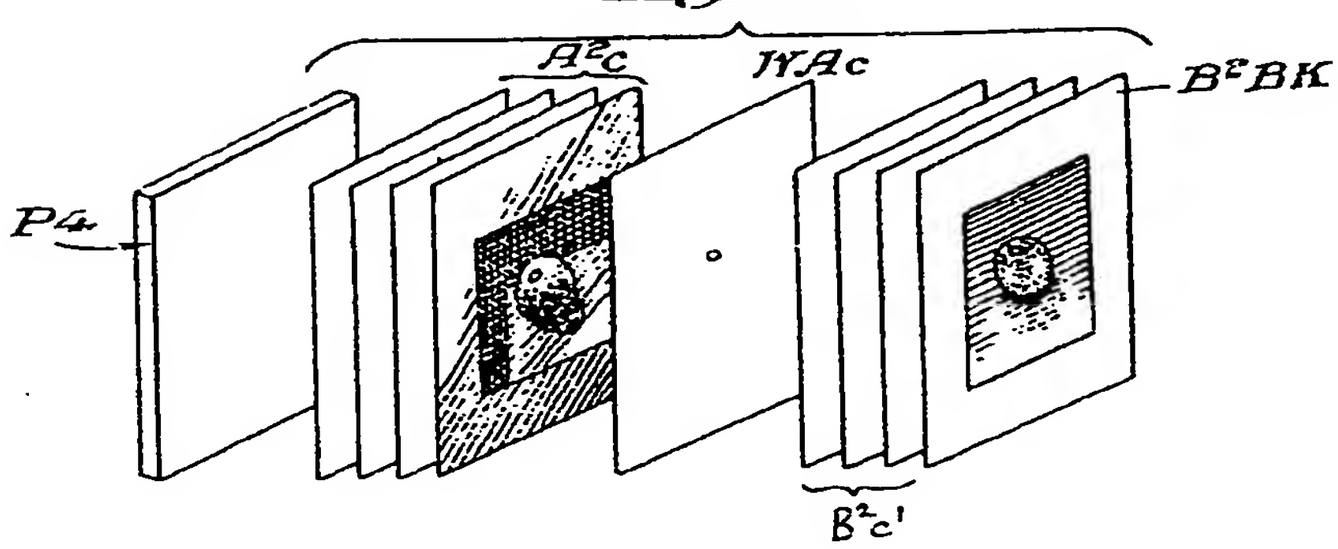
702,051
5 SHEETS

COMPLETE SPECIFICATION

This drawing is a reproduction of the Original on a reduced scale.

SHEETS 4 & 5

Fig. 17.



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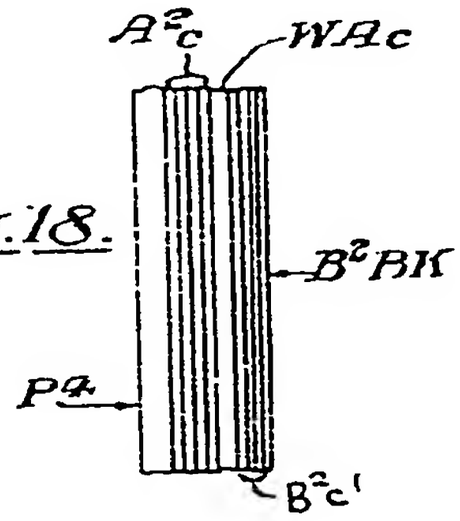

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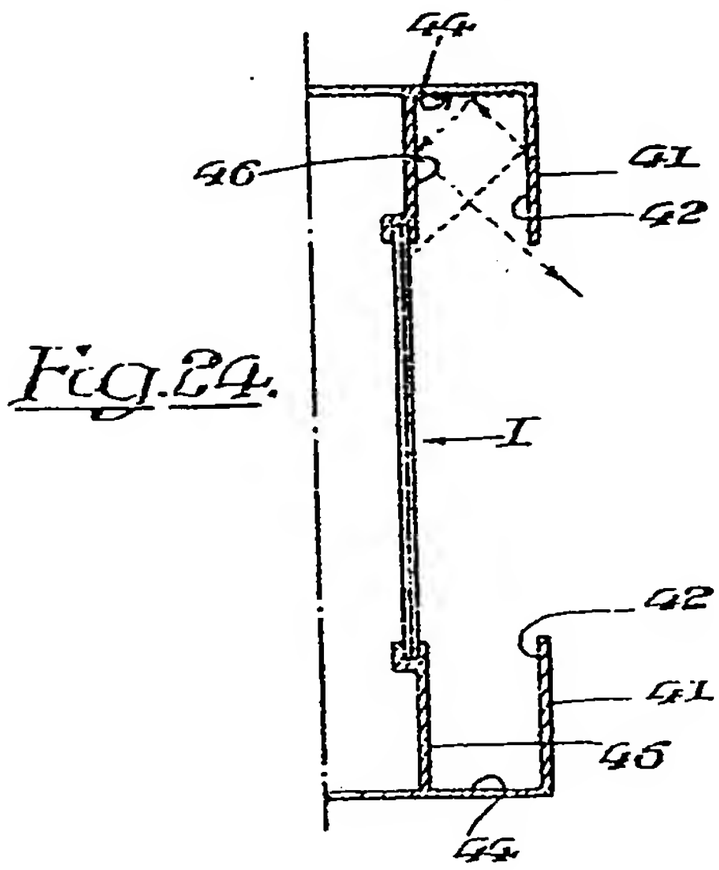

702,051 COMPLETE SPECIFICATION
5 SHEETS
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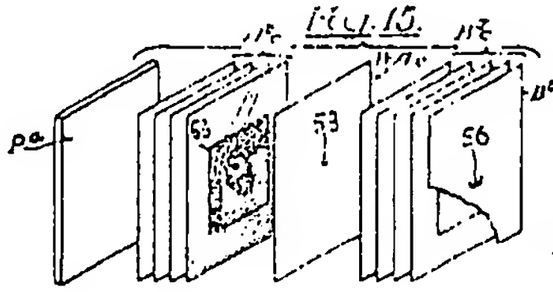
SHEETS 4 & 5

Fig. 15.



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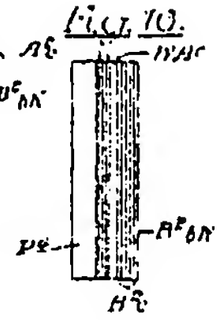

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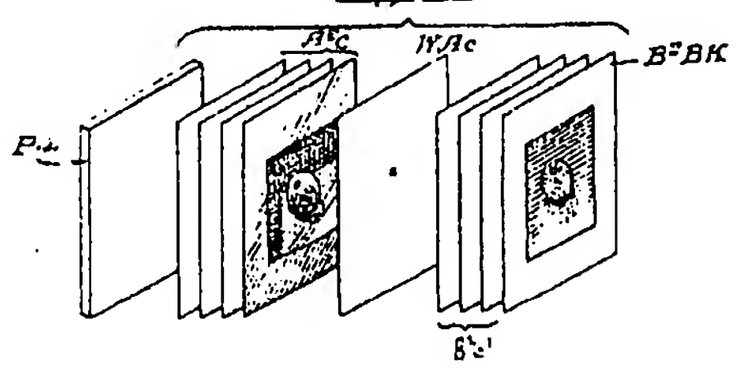

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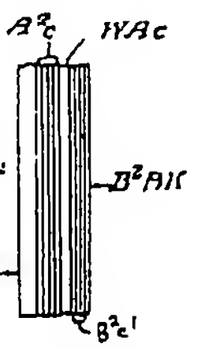

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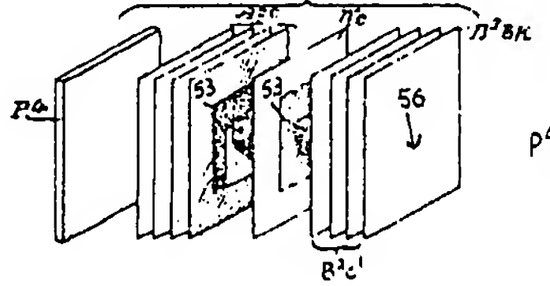

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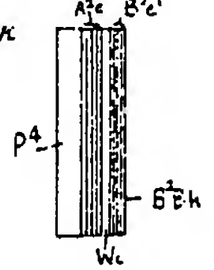

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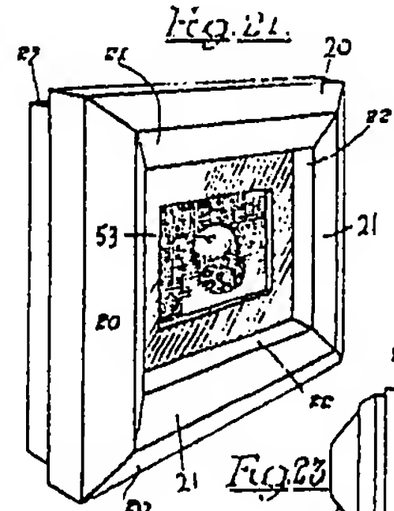

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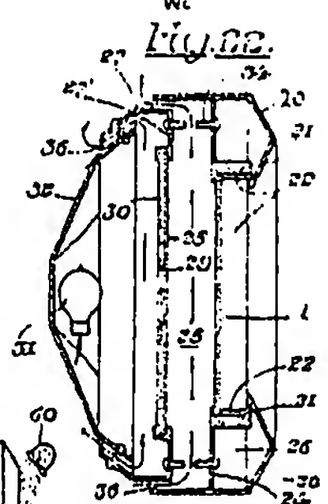

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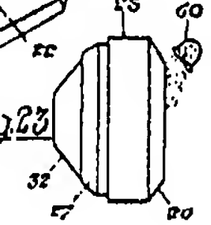

Fig. 24.